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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 25 September 2003 with an application for Letters Patent number 528471 made by Sealegs International Limited.

Dated 1 October 2004.

Neville Harris
Commissioner of Patents, Trade Marks and Designs

COMMISSIONER OF PATENTS, TRADEMARKS & DESIGNS
NEW ZEALAND

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528471

NEW ZEALAND

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PROVISIONAL SPECIFICATION

Title: Retractable Leg Assembly

We, ***Sealegs International Limited***,
Nationality: *A New Zealand company*
Address: *Unit B, 7 Douglas Alexander Parade, Albany, Auckland, New Zealand,*
do hereby declare this invention to be described in the following statement :

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Steerable and retractable leg Assembly

FIELD OF THE INVENTION

This invention relates to an improved leg assembly, in particular, but not exclusively to a steerable and retractable leg assembly for the nose of an amphibious vehicle.

BACKGROUND

Numerous attempts have been made to produce leg assemblies that are suitable for amphibious vehicles. Amphibious vehicles have a number of design challenges, the majority of which centre around the problem of translating the wheels from a deployed position to and from a retracted position.

For the vehicle to work well on the water, the wheels should be well out of the way, and the hull should retain fairly clean lines. And yet when the vehicle is to be used on land, the tyre should be of a suitable size, adequate ground clearance is required, and a method of steering is required.

These diverse requirements have often lead to designs which use significant amounts of space within the vehicle to stow the wheels, and/or have complex systems with doors and seals through which the wheels pass, and when steering is also incorporated, complex methods to engage with some sort of steering system are employed.

Another limitation of previous designs is an inability of the vehicles to retract or extend their wheels when on dry ground, for example to beach the vehicle, or to raise it off the ground again.

This complexity, sometimes coupled with poor use of space, has prevented most of the previous designs from ever becoming a commercial success. Complexity will not only drive costs higher, but also becomes a maintenance burden that is aggravated by operations in salt or even fresh water. A simplified solution is required, having the minimum of moving parts, and the least interruption to the watertight structure of the hull of the vehicle, while in addition having sufficient power to extend the wheels to raise the vehicle off the ground when required to.

OBJECT

It is therefore an object of the present invention to provide a steerable and retractable leg assembly which will at least go some way towards overcoming the above mentioned problems, or at least provide the public with a useful choice.

STATEMENTS OF THE INVENTION

Accordingly, in a first aspect, the invention may broadly be said to consist in a steerable and retractable leg assembly for an amphibious vehicle, comprising;

a leg which is pivotally mountable to the amphibious vehicle and the leg includes a steerable mounting means for at least on ground engagement means,

a linear actuator pivotally mountable to the amphibious vehicle and operatively connected to the leg,

wherein the linear actuator is capable of moving the leg from a retracted position to an extended position, and the arrangement of the assembly is such that during the travel of the leg from the retracted to the extended position, the linear actuator is movable about its pivotal mount to the amphibious vehicle in a manner to ensure that the force exerted on the leg remains substantially constant.

Preferably the arrangement of the assembly is such that during the travel of the leg from the retracted to the extended position, the linear actuator rotates about the pivotal mount to the amphibious vehicle so that the linear actuator acts substantially in the direction of movement of the leg throughout the range of movement of the leg.

Those skilled in the art will appreciate that having the linear actuator acting substantially in the direction of movement of the leg throughout the range of movement of the leg will result in a force being applied to the leg by the actuator which is close to that exerted by the actuator. That is, there will not be a significant loss in the force being applied to the leg resulting from action of the actuator onto the leg at an inefficient crank angle. Such an arrangement paves the way to produce a leg assembly which is capable of lifting the amphibious vehicle off the ground.

The pivoting joints are easier to maintain in a marine environment than sliding joints for example. Also a retractable leg assembly having effectively only two primary moving parts, the leg and the actuator, keeps both initial cost and maintenance to a minimum.

Preferably the leg and linear actuator are so arranged as to form a substantially compact configuration when the leg is in the retracted configuration. This reduces the impact of the lag assembly on living space within the vehicle.

Optionally the leg and the linear actuator are both pivotally mounted onto an adapter plate or fixture which is mountable to an amphibious vehicle. Such a configuration would allow a boat manufacturer to incorporate the leg assembly with a minimum of design changes to his boats.

Preferably the path of travel of the leg from the retracted position to the extended position is external from the substantially water-tight structure of the amphibious vehicle, thus eliminating any requirements for complex doors or seals etc.

Preferably the leg is pivotally mounted adjacent to the bow of the amphibious vehicle.

Preferably the linear actuator is positioned external to the substantially water-tight structure of the amphibious vehicle. This keeps such equipment out of the living space of the vehicle, and indeed positions it in a location which is highly accessible for maintenance purposes.

Preferably the linear actuator is a hydraulic actuator, as hydraulic actuators have been shown to be reliable in marine environments.

Preferably the steerable and retractable leg assembly includes at least one ground engagement means.

Preferably the ground engagement means is at least one wheel.

Preferably the leg is substantially vee or triangular shaped, to provide adequate stability for the leg assembly when in use.

Preferably the steerable and retractable leg assembly includes at least one steering actuator.

Preferably the steering actuator is a hydraulic actuator.

Preferably the steering actuator is connected in series with a waterborne steering system actuator of the amphibious vehicle. This reduces steering system complexity, for example by eliminating the need for additional controls, or systems to disconnect one or other system during waterborne or ground operations. It also reduces operator workload during transitions from water to ground operations.

Preferably the amphibious vehicle in constructed having pontoons running substantially from the bow of the vehicle to the stern, and the leg when in the retracted position, is positioned adjacent to one end of at least one pontoon. The advantage of this being that the stowage is primarily within the lines of the pontoon and therefore of the amphibious vehicle, without using any of the "living space" of the vehicle. The term "living space" being used to mean space otherwise used by the occupants or their belongings or equipment.

Optionally the ground engagement means can be powered, for example by the incorporation of a hydraulic motor within the hub of a wheel or a continuous track assembly.

In a second aspect, the invention may broadly be said to consist in an amphibious vehicle incorporating at least one steerable and retractable leg assembly as specified herein.

DESCRIPTION

The invention may also broadly be said to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of the parts, elements or features, and where specific integers are mentioned herein which have known equivalents, such equivalents are incorporated herein as if they were individually set forth.

One preferred form of the invention will now be described, by way of example only, with reference to the accompanying drawings in which,

FIGURE 1 is a perspective view of a steerable and retractable leg assembly,

FIGURE 2 is a plan view of a leg used in the steerable and retractable leg assembly,

FIGURE 3 is a partial perspective view showing an amphibious vehicle incorporating the steerable and retractable leg assembly, in a retracted position.

FIGURE 4 is a photograph of the steerable and retractable leg assembly shown in a fully extended position,

FIGURE 5 is a photograph of the steerable and retractable leg assembly shown in an intermediate position,

FIGURE 6 is a photograph of the steerable and retractable leg assembly shown in a fully retracted position, and

FIGURE 7 is a photograph of the steering actuator.

FIGURE 8 is a schematic diagram showing the basics of the steering hydraulic circuit.

With reference to **Figure 1**, a steerable and retractable leg assembly (10) is manufactured comprising at least a leg (11), a wheel (13) and a steering actuator (15). The leg (11) is pivotally mounted to the hull (17) of an amphibious vehicle via bearings (not shown) mounted in the hull (17) arranged about axis (19). In this example a shaft extends from one side of the hull (17) to the other, and the leg is supported by two bearings, one mounted within each side of the hull (17).

In the preferred form the axis (19) is above the waterline of the amphibious vehicle.

The leg comprises an upper frame assembly (21) and a yoke assembly (23). The yoke assembly (23) is pivotally mounted to the upper frame assembly (21) to enable steering of the wheel (13). To effect controlled steering of the wheel (13), the steering actuator (15) is provided. The steering actuator (15) is mounted onto the upper frame assembly (21) and acts via a connecting rod (25), and an arm (27) which is rigidly attached to the yoke assembly (23), to alter (29) the orientation of the yoke assembly (23).

In this example the steering actuator (15) is a hydraulically operated actuator. In a first prototype the hydraulic power is supplied to the steering actuator (15) via flexible lines (31). However in a preferred embodiment, the hydraulic power is supplied via supply lines which is internal to or integral with the leg (11). This eliminates the problems caused by long flexible lines which are caused to move about during operation of the leg assembly (10).

Also shown in Figure 1 is a linear actuator (33) which can be used to move the leg (11) from an extended position as shown to a retracted position. The linear actuator (33) is mounted onto the hull (17) by a pivoting joint (34), and the rod (36) of the actuator (33) is connected to a bracket (12) on the leg (11). Movement (35) of the rod (36) of the actuator (33) causes the leg (11) to move in the direction (37) to a retracted position. As the leg (11) moves to a retracted position, the actuator (33) rotates in direction (39). To allow for this movement (39), and to keep the overall configuration compact, the hull (17) has been appropriately shaped (41) providing a recess into which the actuator can travel.

Not shown in Figure 1 are pontoons which are fitted to the exterior of the hull of the amphibious vehicle (17). The leg (11) and wheel (13) when in a retracted position lie between the forward ends of the pontoons mounted to each side of the hull (17). This is shown in a later figure.

With reference to **Figure 2**, the leg (11) is shown in a plan view. The leg comprises a triangular shaped upper frame assembly (21) and a yoke assembly (23). As noted with reference to figure 1, the yoke assembly (23) is pivotally connected to the upper frame assembly (21). A mounting face (22) is provided to mount the steering actuator (15), and a bracket (12) is provided as a point to attach the rod (36) of the linear actuator (33).

With reference to **Figure 3**, an amphibious vehicle (50) is shown incorporating a steerable and retractable leg assembly (10) as described herein. The steerable and retractable leg assembly (10) is shown in a retracted position, between the forward ends of pontoons (43) which are fitted to each side of the hull (17) of the amphibious vehicle (50).

With reference to **Figures 4, 5** and **6**, photographs are provided of the steerable and retractable leg assembly (10) fitted to a hull (17). Figure 4 shows the leg assembly (10) in an extended position, figure 5 shows the leg assembly (10) in an intermediate position part way between an extended position and a retracted position, and figure 6 shows the leg assembly (10) in a fully retracted position. In these photographs the pontoons of the amphibious vehicle (50) are not shown.

A number of advantageous features of the operation of the linear actuator (33) can be seen in the sequence of photographs. The actuator (33) is pivotally mounted (34) to the hull (17)

and pivots about the end of the actuator from which the rod (36) extends. It is positioned relative to the leg (11) in such a way as to operate at or near a right angle, or at least at an effective crank angle, to the leg (11). That is, as the leg (11) rotates from an extended position to a retracted position, the actuator (33) pivots about its' mounting point, and maintains an effective crank angle relative to the leg (11) at all times. This means that the leg (11) experiences a force the same as, or close to, the maximum force that the actuator can exert at all times, or put another way, the force exerted by the actuator (33) is not significantly reduced at any stage due to operation at an inefficient crank angle.

This has four principal advantages. Firstly, the actuator (33) can act as a robust up-lock actuator, that is it can support the leg (11) in the retracted position even during operation of the vehicle (50) in rough seas. Secondly, the actuator (33) can act as a robust down-lock actuator, that is it can support the leg (11) in the extended position and act as a sturdy brace during ground operations. Thirdly, the actuator (33) can act with sufficient force to move the leg (11) from the retracted position to the extended position when the vehicle (50) is on dry ground, allowing the vehicle (50) to lift itself off the ground, or conversely to lower itself onto the ground – see figure 5 in which the actuator (33) is operating at very close to 90 degrees to the leg (11) at the time when the vehicle (50) would begin to lift off the ground. And fourthly, the steerable and retractable leg assembly (10) forms a relatively compact configuration in the retracted position – this can be seen most clearly in figure 6.

In addition to all of these advantages, the steerable and retractable leg assembly (10) is compact when the leg (11) is in the retracted position, and yet provides considerable ground clearance for the vehicle when the leg (11) is in the extended position.

With reference to **Figure 7**, a photograph is provided showing the steering actuator (15) and the connecting rod (25) attached to the arm (27).

With reference to **Figure 8,** a schematic diagram shows the basics of the steering hydraulic circuit. The inventor has found that it is convenient to integrate the ground based steering system with the waterborne steering system of the amphibious vehicle, that is to integrate the ground based steering system with the steering system for the outboard motor for example. To avoid the need for complex systems to engage or disengage the ground based steering

and/or the waterborne steering, the two systems are integrated so that they both operate all of the time.

To achieve this both the waterborne steering system actuator (53) and the ground based steering system actuator (15) are linked in series. To enable this method to work, the fluid volume displacements of the waterborne steering system actuator (53) and the ground based steering system actuator (15) need to be matched. That is, if it takes 200 millilitres of fluid to displace the waterborne steering system actuator (53) from a central steering position to full left, then the ground based steering system actuator (15) is sized in respect of diameter and stroke to use the same volume of fluid to move from a central steering position to full left position. Those skilled in the art will appreciate that a narrow actuator (53) with a long stroke (63) may be matched with a larger diameter actuator (15) of shorter stroke (63) and still meet the requirements of similar fluid volume displacement.

Figure 7 shows a hydraulic circuit in which a hydraulic power supply (55) supplies hydraulic fluid at pressure to a steering control valve (57). The steering control valve is controlled via inputs from the vehicle's steering wheel (59). From the steering control valve (57) hydraulic fluid can be supplied in both directions to the waterborne steering system actuator (53) and the ground based steering system actuator (15) which are linked in series.

A manual bypass valve (61) can be used when required to synchronise the two actuators (53) and (15).

VARIATIONS

Electrically, pneumatically or manually powered actuators can be used in place of any of the hydraulically powered actuators (15) or (33).

The leg (11) can rest against a hard point on the hull of the amphibious vehicle (17) when in the extended position to help transmit loads between the leg (11) and the hull of the amphibious vehicle (17) during ground operations. To this effect a vee shaped block of a resilient material, for example rubber, can be secured to the leg (11), the vee shaped block being so sized, shaped and oriented to mate with the lower surface of the hull (17) of any vehicle (50) to which the leg (11) is attached. Additional structure can be added to the hull of the vehicle to help spread the loads into the hull.

In a further variation the wheel (13) could be powered, for example by a hydraulic motor mounted within the hub of the wheel (13).

ADVANTAGES

Thus it can be seen that at least the preferred form of the invention provides a steerable and retractable leg assembly which is simple and robust, and which uses up very little living space of the amphibious vehicle. This is advantageous.

Throughout this specification the word "comprise" and variations of that word, such as "comprises" and "comprising", are not intended to exclude other additives, components, integers or steps.

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Attorneys for:

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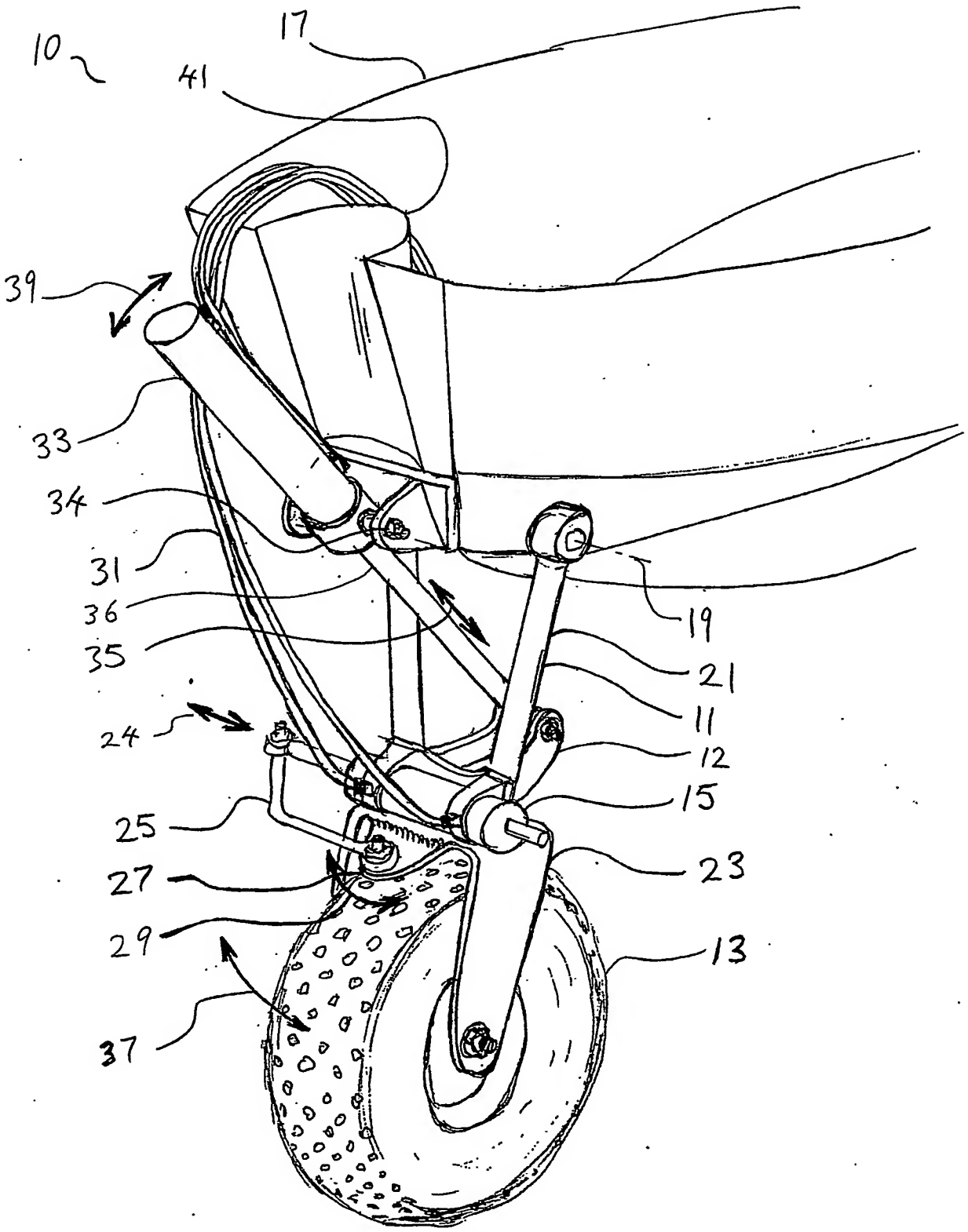

Figure 1

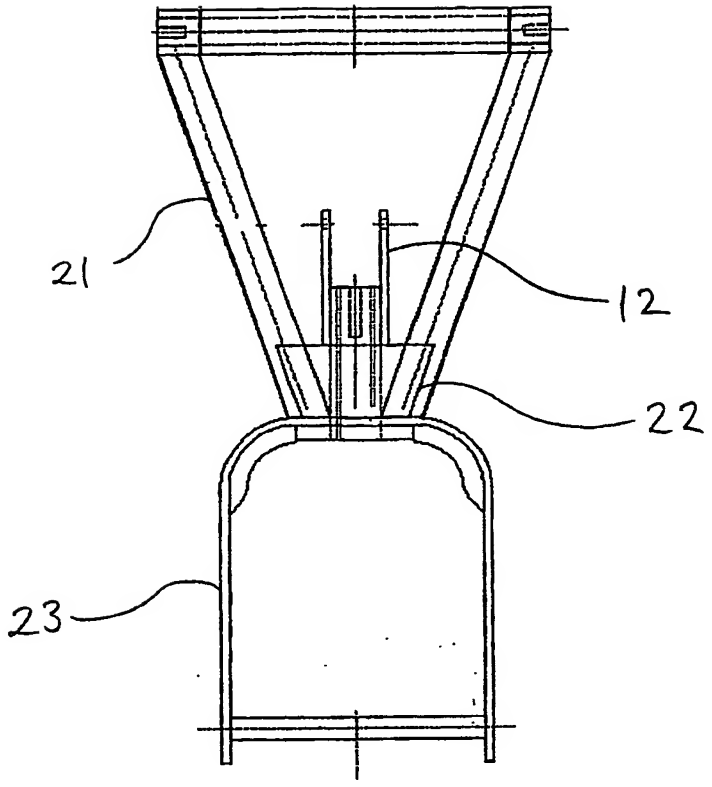

Figure 2

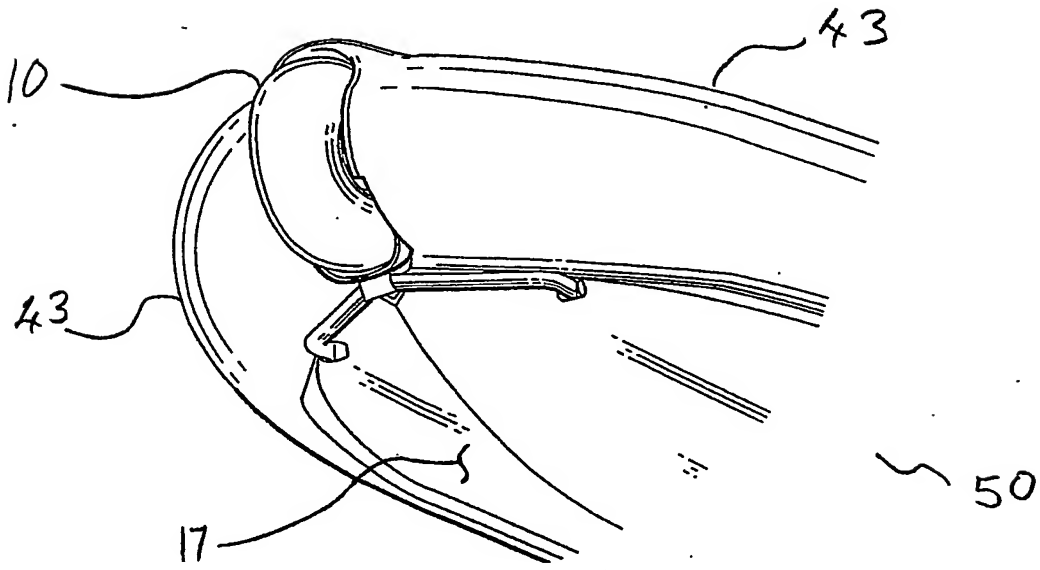

Figure 3

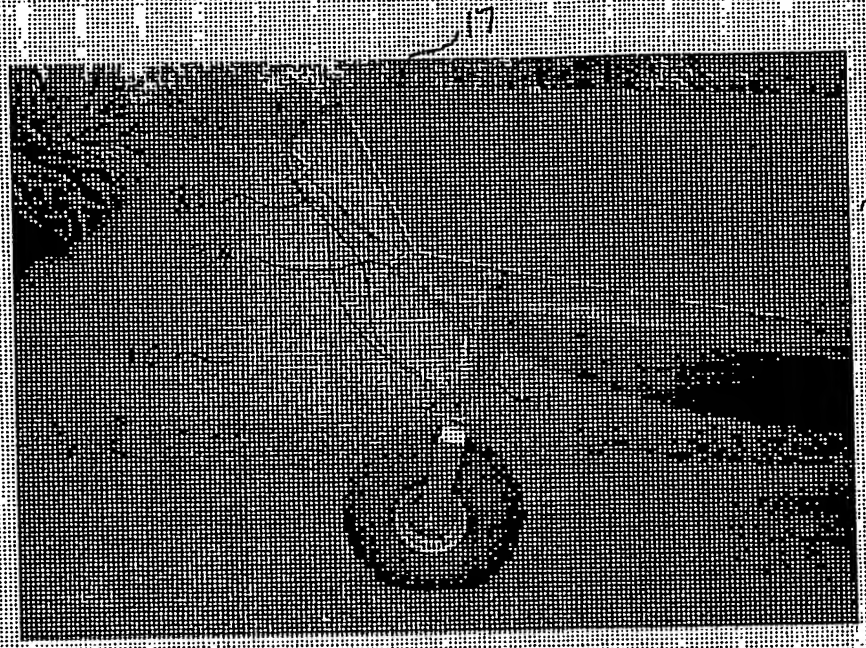

Figure 4

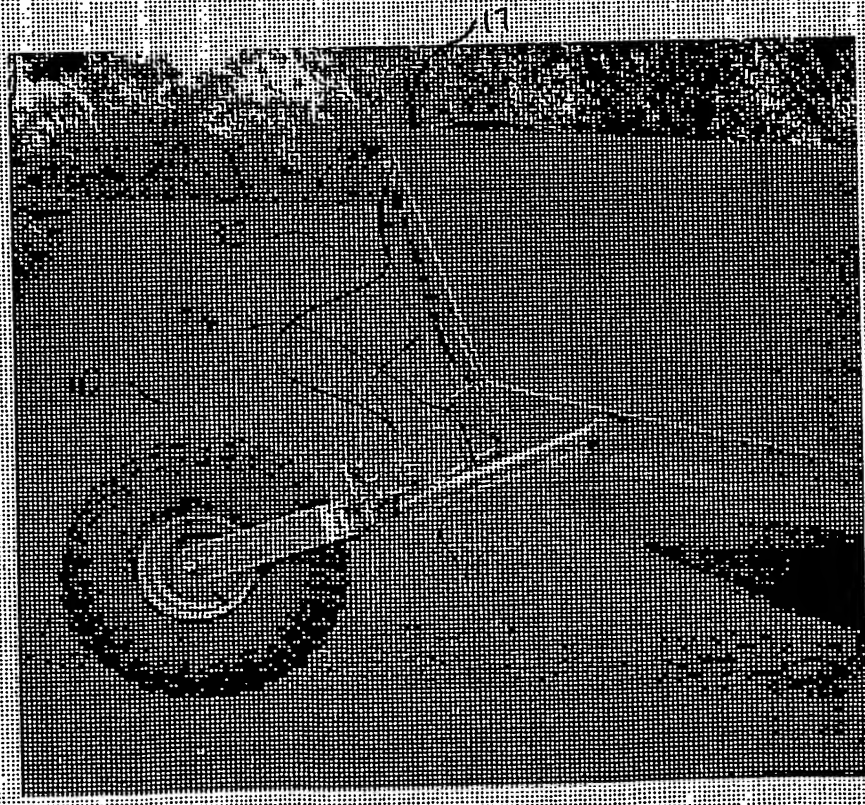

Figure 5

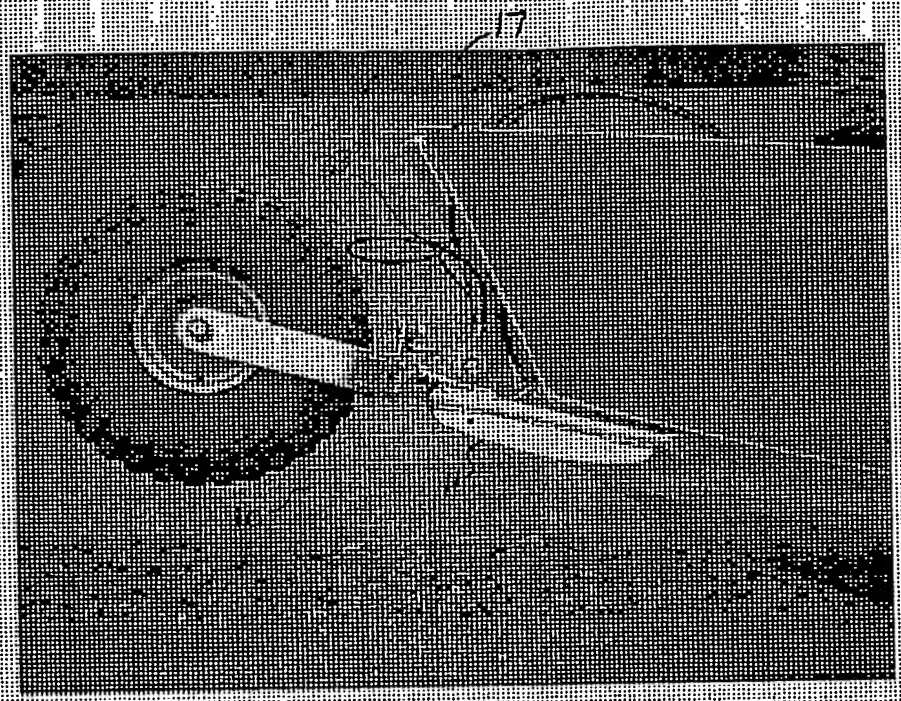

Figure 6

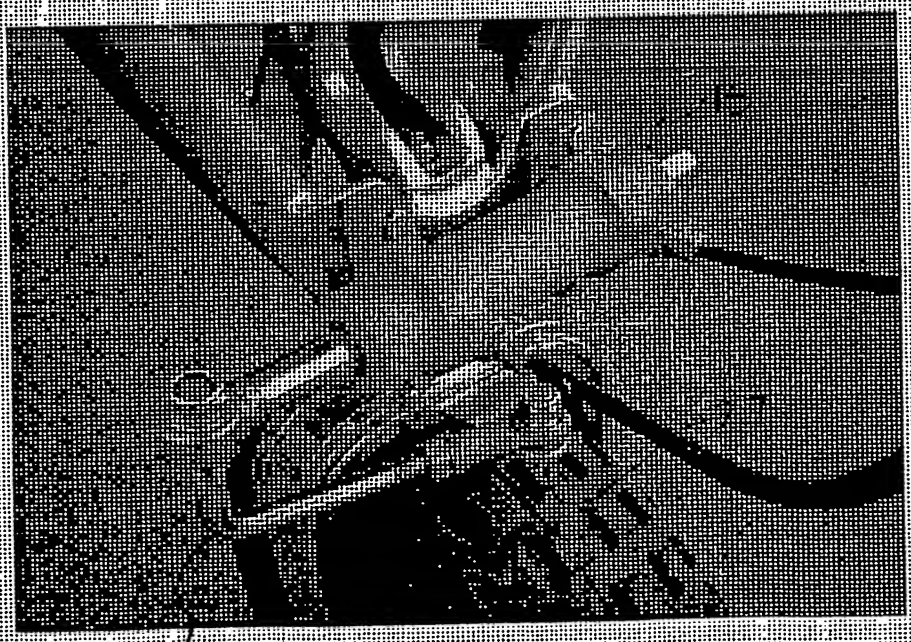

Figure 7

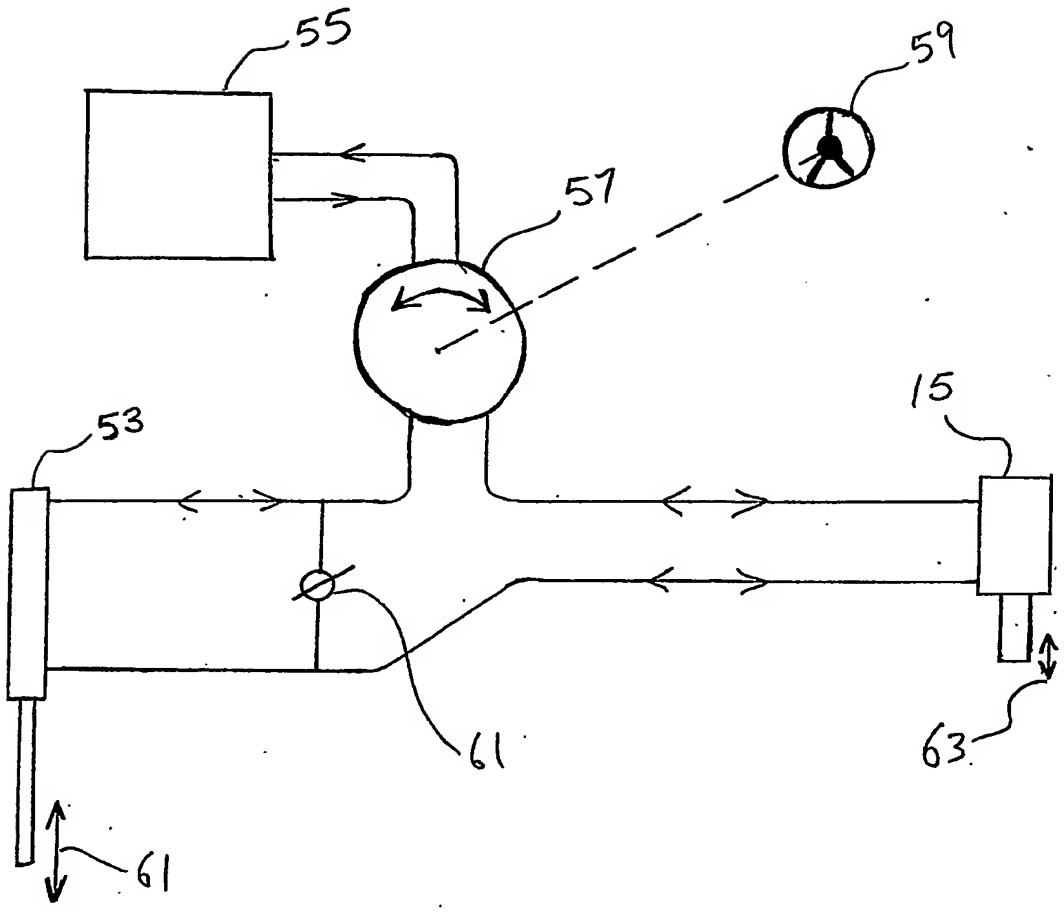

Figure 8

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